Fu-Liou Online Code Users Manual

FLP200503 differential version
http://snowdog.larc.nasa.gov/cgi-bin/rose/flp200503/flp200503.cgi

The following is a description of the inputs

Compute:
Press to initiate a radiative transfer computation **or** a change in the input panel.

Case:

- A – Results computed, displayed and saved as case A
- B – Results will computed and displayed for case B
    - In addition outputs for case B *minus* case A displayed

Forcing:
The difference of two computations using different assumed states.

- Cloud + Aerosol
  (Clouds + Aerosols) *minus* (Pristine)
- Cloud
  (Clouds + Aerosols) *minus* (Aerosols only)
- Aerosol
  (Clouds + Aerosols) *minus* (Clouds only)

Output:
What outputs are to be displayed,

- Profile
  Vertical profiles of Shortwave, Longwave and Window Flux at several Pressure levels (Lo resolution 4 levels, Hi resolution 120 levels)
- BB Table
  Concise table of TOA and Surface fluxes and their forceing
- Spec_Toa_Alb
  Table of TOA spectral albedo in the 15 SW bands and their forceing
- Spec_Trans
  Table of surface spectral transmission in the 15 SW bands and their forceing
- Spec_toa_LW
  Table of spectral TOA longwave flux in the 14 LW bands and their forceing
- Spec_SFC_LWDN
  Table of spectral surface downwelling longwave flux in the 14 LW bands and their forceing
- LW_WN_Radiance
  Table of Longwave and window TOA radiance at the chosen view zenith angle , Toa flux and anisotropy.

- INPUT_Details
  ASCII printout of all the model inputs.
- OUTPUT_Details
  ASCII printout of all the model outputs.

Atmosphere:
Allows selection of pressure, temperature, water vapor and ozone vertical profiles.

Choose from 5 standard atmospheres:

- Tropical
- Mid-latitude summer
- Mid-latitude winter
- Sub-arctic summer
- Sub-arctic winter

<u>No Edit:</u>
Use selected standard atmosphere as is.

<u>Simple Edit:</u>

- Modify precipitable water profile of standard atmosphere below 500hpa(%)
- Modify precipitable water profile of standard atmosphere above 500hPa (%)
- Modify total column ozone amount. (%)
- Modify temperature lapse rate (K/Km)
- Modify skin temperature (K)
- Modify Longwave surface emissivity

<u>Detail Edit:</u>
Modify or input an atmosphere profile of your choosing.

Cosine Solar Zenith Angle:
The amount of incoming solar energy and path-length thru the atmosphere is determined. Cosine solar zenith equals 1.0 for overhead sun. Solar constant set to 1365 Wm^{-2}

Cosine View Zenith Angle:
For the Longwave radiance computation the cosine of the view angle (angle from nadir) is needed. Shortwave radiance is **not** computed by this model.

Streams:
The Fu-Liou model has options for 3 computation modes a

- 2-stream
- 2-stream GWTSA(Gamma Weighted Two-Stream Algorithm) <u>Shortwave Only</u>
- 4-stream

Surface Albedo:

- IGBP – An assignment of spectral albedo is made based on that associated with the International Global Biosphere Product (IGBP) category.
- Numerical value – A broadband surface albedo value

Spectral IGBP:

- FLAT – The numerical input value of the broadband surface albedo is assumed spectrally flat.
- 1-20 – An IGBP classification type and associated spectral surface albedo shape.
    - A numerical value of surface albedo adjusts the selected spectral shape to give the approximate broadband surface albedo value. Otherwise the unadjusted IGBP spectral albedo is used.
    - 17-OCEAN For the Ocean case spectral surface albedo comes from a look-up-table based upon COART (Jin 2004) using inputs of
        - Cosine Solar Zenith angle
        - Total Optical Depth
        - Wind speed (m sec^{-1})
        - Chlorophyll (mg m^{-3})
        - Correction for sea foam, (wind speed based)

Carbon Dioxide :
Abundance of CO2 (ppmv) found well mixed in the atmosphere. Changing the CO2 concentration does NOT affect the Shortwave CO2 absorption.

Longwave Continuum :
Choice of the formulation of longwave continuum absorption

- Roberts (mainly in the window region)
- Clough et al (CKD_2.1).
- Clough et al (CKD_2.4).
- OFF: No Longwave continuum parameterization.

Surface Elevation:
The surface boundary condition (albedo , skin temperature & emissivity) are placed at this elevation in meters.

Vertical Resolution:

- Lo - ~ 35 computational levels and 5 output levels
- Hi - ~120 computational levels and 120 output levels

Clouds

Two overlapping cloud layers are allowed to be input in this online version.

Visible Cloud Optical depth:

The optical depth of a cloud is used as input to determine the physical property of liquid or ice water content (g/m3). From there the Fu-Liou model determines the scattering properties for all wavelength bands. The Fu-Liou model inputs here are visible cloud optical depth, phase, particle size, cloud top and base. Functional relationships determined by (P. Minnis) use visible cloud optical depth, particle size, phase to determine water content.

Cloud Levels:
Selection of cloud top and base using pressure coordinates hectopascals (hPa)

Phase:
Clouds are input as either WATER or ICE phase. This affects the input of cloud particle size.

Inhomogeniety: (2-stream GWTSA Only)
This is the shape factor ν of the gamma distribution for the Gamma Weighted Two-Stream Solver (GWTSA). It can be estimated by where τ is the mean cloud optical depth and σ is its standard deviation ($\nu = (\tau/\sigma)^2$)

Cloud Particle Size:
Water cloud effective radius (R_e) useable range: 5-30 μ
Ice cloud effective diameter (D_e) useable range: 20-180μ

Scattering and absorption by clouds is affected by the particle size of a given cloud. Water clouds usually range from 4 to 30 microns in radius while ice clouds have typical effective diameters of >30 microns. The model does not give reasonable results for ice cloud diameters < ~20 microns. A parameterization is used to convert from the input definition to Generalized Effective Diameter (Dge) which is the basis of the ice cloud optical properties (Fu 1996).

Aerosols

Two aerosol constituents are allowed as inputs

Aerosol Optical depth:)
Aerosol optical depth at 0.63μ . Spectral dependence of the optical depth is affected by the choice of aerosol type

Aerosol Type:
Aerosol type is used to determine the spectral normalized extinction, scattering and absorption properties of the aerosol. 25 aerosol types are featured from these sources.

- d'Almedia (Types 1-3)
- Tegin&Lacis (Types 4-8)
- OPAC Version 3.1a (Types 9-18)
- Lacis 2004 (Types 19-25)

1. Maritime (8 sets of RH dependent properties)
2. Continental (8 sets of RH dependent properties)
3. Urban (8 sets of RH dependent properties)
4. 0.5 Micron Mineral_Dust
5. 1.0 Micron Mineral_Dust
6. 2.0 Micron Mineral_Dust
7. 4.0 Micron Mineral_Dust
8. 8.0 Micron Mineral_Dust
9. 'inso' Insoluble
10. 'waso' Water Soluble (8 sets of RH dependent properties)
11. 'soot' Soot
12. 'ssam' Sea Salt (Accumulation Mode) (8 sets of RH dependent properties)
13. 'sscm' Sea Salt (Coarse Mode) (8 sets of RH dependent properties)
14. 'minm', Mineral Dust (Nucleation Mode)
15. 'miam', Mineral Dust (Accumulation Mode)
16. 'micm' Mineral Dust (Coarse Mode)
17. 'mitr' Mineral Dust (Transported Mode)
18. 'suso' Sulfate Droplets (8 sets of RH dependent properties)
19. 0.5 Micron Mineral_Dust (Lacis 2004)
20. 1.0 Micron Mineral_Dust (Lacis 2004)
21. 2.0 Micron Mineral_Dust (Lacis 2004)
22. 4.0 Micron Mineral_Dust (Lacis 2004)
23. 8.0 Micron Mineral_Dust (Lacis 2004)
24. [0.1-0.5]um bin of LogNorm Dist to Lacis Dust for re=0.298 sig=2
25. [0.5-5.0]um bin of LogNorm Dist to Lacis Dust for re=0.298 sig=2

Aerosol Profile Scale Height (km):
Scale height at which aerosol loading goes to 1/e of surface value. A NEGATIVE input value places all aerosol loading for that constituent in a single model layer, where "–1" corresponds to the surface layer, "–15" the 15th layer above the surface.

References:

Fu, Q., and K.-N. Liou, 1993: Parameterization of the radiative properties of cirrus clouds. J. Atmos. Sci., 50, 2008-2025.

Fu, Q., and K.-N. Liou, 1992: On the correlated k-distribution method for radiative transfer in nonhomogenous atmospheres. J. Atmos. Sci., 49, 2139-2156.

d'Almeida, G. A., P. Koepke, and E. P. Shettle, 1991: Atmospheric aerosols - global climatology and radiative characteristics. A. Deepak Publishing, Hampton, Va, 561 pp.

Clough, S.A., F.X. Kneizys, and R.W.Davies, 1989: Line shape and the water vapor continuum. Atmos. Res., Vol. 23, 229-241.

Tegen, I., and A. A. Lacis, 1996: Modeling of particle size distribution and its influence on the radiative properties of mineral dust aerosol. J.Geophy. Res., 101, 19237-19244.

Kato, S., and F. G. Rose, and T. P. Charlock, 2004: Computation of Domain-averaged Irradiance Using Satellite-derived Cloud Properties, J. Atmos. Oceanic Technol., in press.

Kato, S., T. P. Ackerman, J. H. Mather, and E. E. Clothiaux, 1999: The k-distribution method and correlated-k approximation for a Shortwave Radiative Transfer Model, J. Quant. Spectrosc. Radiat. Transfer, 62, 109-121.

Charlock, T. P., and T. L. Alberta, 1996: The CERES/ARM/GEWEX Experiment (CAGEX) for the retrieval of radiative fluxes with satellite data. Bull. Amer. Meteor. Soc., 77, 2673-2683..

Fu, Q., G. Lesins, J. Higgins, T. Charlock, P. Chylek, and J. Michalsky, 1998: Broadband water vapor absorption of solar radiation tested using ARM data. Geophys. Res. Lett., 25, 1169-1172.

Fu, Q., K. Liou, M. Cribb, T. Charlock, and A Grossman, 1997: On multiple scattering in thermal infrared radiative transfer. J. Atmos. Sci., 54, 2799-2812.

Fu, Q., W.B. Sun, and P. Yang, 1999: Modeling of scattering and absorption by nonspherical cirrus ice particles at thermal infrared wavelengths. J.Atmos. Sci., 56, 2937-2947.

Hess, M., P. Koepke, and I. Schult, 1998: Optical Properties of Aerosols and Clouds: The software package OPAC. Bull. Amer. Meteor. Soc., 79, 831-844.

Kratz, D. P., and F. G. Rose, 1999: Accounting for molecular absorption within the spectral range of the CERES window channel. J. Quant. Spectrosc. Radiat. Transfer, 48, 83-95.

Rose, F. G., and T. P. Charlock, 2002: New Fu-Liou Code Tested with ARM Raman Lidar and CERES in pre-CALIPSO Exercise. Extended abstract for 11th Conference on Atmospheric Radiation (AMS), 3-7 June 2002 in Ogden, Utah.